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HOW SCIENCE SERVES THE PEOPLE.

BY E. RENAN.

I HAVE heard that General Grant laid the foundation of his exalted career in the reputation which he gained as a teacher in those Sunday schools which have so largely contributed to the spread of popular instruction in America. With a profound sense of right, far more discerning than the cleverness of our most astute politicians, the great American republic has realized that moral and intellectual training forms three-quarters, and perhaps much more, of the influences that are most effective in the making of a man, and that to labor for the instruction and the education of its citizens is to create wealth for the country, to insure its progress, to preserve it from revolution, and to gain for it the only glory to be desired in modern times, that of peace and liberty. I shall not dwell upon this point; it is too obvious to need demonstration.

One speaks almost without contradiction, at least without avowed opposition, when one speaks of the necessity of public instruction, and of elementary instruction in particular. I propose to discuss a more difficult question, that of the necessity of higher education, the necessity of scientific teaching. I wish to prove that researches apparently most barren, in which but a very small number of persons can take intelligent interest, are often those which yield the most important results, and contribute most directly to the welfare of the people. One hears people—not infrequently even friends of the public weal, who desire progress—contend that fields of research which are purely scientific should be abandoned to the curious and to amateurs, and that the state should not concern itself with them. There are, for instance, at the College of France—that great institution which represents the highest developments of science—Chairs of

Mathematics and advanced Chemistry, which are attended by less than ten students, simply because there are not twenty persons in Paris capable of understanding what they teach. What is the use, it is asked, of lavishing the funds of the state upon such instruction? How do chairs like these contribute to the education of the people? Would it not be better to employ the money spent upon them in providing courses more accessible, by which a great number of citizens might benefit? I hope to prove that this is a mistaken idea, that there are no chairs more useful than these, and no money better spent than that applied to their maintenance. I hope to prove that, very far from being indifferent to the democracy, pure science renders it the greatest services, and contributes largely toward the great end of democracy, the emancipation of the people and the amelioration of their condition.

It is evident, at the outset, that each practical discovery made by the human mind involves a corresponding progress in moral condition, an advance in dignity, for the entire race. Upon the monuments of Nineveh, built nearly three thousand years ago, are represented the methods of erecting the colossal figures which adorned these monuments, and some specimens of which may be seen in the Louvre. The mode of traction is wonderfully simple. Hundreds of men, yoked and attached by ropes about their necks, drew the colossal bull by the tension of their muscles. To each ten men was an overseer who distributed blows with a stick, at random, as we would not do now even with horses.

That was horrible! It was due to the fact that they had no machines, even the brutes were little used; the limbs of man formed almost their only motive force.

Take an ancient galley, one of those great Greek ships so admirably constructed; what is its motive force? It is, again, the strength of the arms of men. Inside this beautiful ship there was a hell! Hundreds of human beings, piled upon one another in a manner difficult to conceive, whose life was a perpetual groan, and who were subjected to the most cruel treatment, moved the oars and propelled the ship. This continued almost to our own times. We have pictures of the interior of a galley in the time of Louis XIV., and they are enough to make one's hair stand on end. It is not without reason that the word "galley" has remained in our language as a synonym of the most dreadful kind of forced labor. Why these horrors? There was no steam then; the art of navigation was in its infancy. The arm of man applied directly to the oar was the only means of propulsion. Take, on the other hand, our largest steamers; the muscular effort expended in their navigation is almost insignificant.

In ancient times, there was another kind of labor, almost as arduous as that of the oar, that of the mill-stone. There were neither wind mills nor water mills; grain was ground by the strength of the human arm, between two stones, one conical, the other fitting over it. To turn the grindstone was synonymous with the most cruel punishment. With the invention of mills this frightful occupation disappeared.

There are no inventions, not even the most deadly, which have not served the cause of civilization. Before the invention of gunpowder, the man who had a good horse and serviceable armor was so much the superior of the unarmed man that the unarmed man could do nothing but submit; since the introduction of gunpowder and artillery, the superiority of the horseman, of the feudal seigneur, has ceased. Every man, if he have only courage, is the equal of every other. Laws, our great modern States, the negations of feudality, have been created. Nothing proves better the solidarity of humanity. A discovery made at one end of the world becomes an emancipator, an instrument of progress, to men at the other end. A savant in seclusion detects a law of nature, and this law, when it is recognized, brings about the abolition of torture, of pain, and of inherited disgrace; an abstract calculation leads to measures of the loftiest philanthropy.

Let us study the origin of those inventions which have relieved mankind from a multitude of evils and of cruel hardships. They have originated in two ways. Among those numberless inventions which are so interwoven with our lives that we have almost ceased to think of them, there are certain immemorial ones which seem as old as the world itself, whose originators are unknown, and which were not the result of scientific research. Who invented our domestic utensils, the implements of agriculture and of our ordinary handicrafts, and the practice of all our mechanical arts No one knows. Assuredly, they who introduced vehicles, the mariner's compass, printing, metal work, distillation, gunpowder, who discovered the principles of agriculture and of navigation, were not men of mediocre ability. But they were not exactly scientists, experimenting, working out in laboratories these discoveries, which, indeed, demanded clear and ingenious minds, but not a profound theory of nature, nor a close chain of reasoning. These discoveries were made in an empirical manner, and not as the result of profound calculations.

On the contrary, there are other inventions which presuppose a broad study of the laws of nature. Men, however ingenious, who had not had the advantage of the acquisitions of organized science, could never have discovered the use of steam, the electric telegraph, illuminating gas, the telescope or photography. These are scientific discoveries which imply organized science. Henceforth, there are scarcely any others to make. The field of instinctive discoveries, in some sort empiric, is exhausted; nothing more is to be found in the highways; we must betake ourselves to the most remote and unfrequented byways. There is no longer any way of creating new instruments for the service of man, unless one resorts to the most profound analysis, an analysis so profound that it is intelligible only to a very small number. Some examples will make my thought plain.

In 1819 and 1820, there were, at Paris and at Copenhagen, two savants, equally unknown, equally immersed in researches to all appearance most incomprehensible; the Dane was called Oersted, the Frenchman Ampère. On September 11th, 1820, the Dane observed a fact which impressed him, the effect produced by a wire, when traversed by an electric current, upon a magnetic needle in its vicinity. Ampère was cognizant of the fact observed by Oersted; he had long been occupied with the same train of thought; seven days later, he announced to the Academy of Sciences a fact much more general, that two threads, conjoined and parallel, attract each other when the electric current passes through them in the same direction, and repel each other when the currents traverse them in opposite directions. The phenomena of electro-magnetism and electro-dynamics were discovered. By deductions, too lengthy to be entered upon here, electric telegraphy was invented. Ampère set up in his laboratory a small apparatus, differing only from those in constant use around us in size and in practical application. There, then, is a discovery of the first importance, which has influenced every department of life, which has a future we can scarcely foresee, which issued from the laboratories of two savants absorbed in the most abstruse studies. Ampère was an ordinary professor; he was absent-minded, odd, obscure. Here, if ever, was an opportunity to make the objection which I am answering. "Are studies of this kind really useful? Would it not be better to have a man who would popularize knowledge, who would attract crowds to his lectures?" And you see how ill-founded the objection is. This course of study, little understood, little appreciated, gave birth to an invention which has become essential to humanity, which has without doubt helped to change the face of the earth.

I might refer to numerous other examples. Was the power of steam discovered empirically and fortuitously? Not at all. Papin and Watt were scientists, thorough scientists, and without long experiment no one could have made this discovery, the most extraordinary which can be cited. Lighting by gas is the consequence of the theory of gases, but the theory of gases would never have been arrived at but for the obscure labors of the chemists of the last century. Electric lighting has its origin in the knowledge of a force scarcely perceptible in nature, a force whose existence man deduces from insignificant facts, the attraction of amber, the torpedo fish, and from a phenomenon which has nothing apparently in common with these, namely, lightning. We may say the same of electro-metallurgy.

The progress of navigation, in the same way, is due to science. Compare the seamanship of our day with that of the past. What a difference! Formerly, men sailed from cape to cape; they feared to lose sight of land. Now the daring of voyagers knows no limits. To whom is this advance due? To Galileo, to Newton. The determination of longitude, the fundamental problem of navigation, was the result of the most abstruse investigations, from which have been deduced processes which the simplest sailor practices almost mechanically. Then remember what Galileo and Newton were—speculative scientists absorbed in the most abstract problems and the deepest calculations. The calculations of Newton, in particular, were so complex that in all Europe there were not more than ten persons who could follow them, and he himself at times almost lost the thread of them.

I should never be done if I were to enumerate all the well known discoveries which have resulted from abstract science.

Photography, with its varied and instructive applications, would have been impossible without the development of the theory of light. The discovery itself was largely empiric. Niepce and Daguerre proceeded in the most singular fashion. We cannot call them scientists, like Ampère and Oersted; but they were men acquainted with the teaching of science, and took advantage of instruments contrived before their time.

Shall I speak of chemistry, of those astonishing applications which have transformed industry, and have led to such an enormous increase in wealth, to the advantage of educated and civilized peoples? The discovery of artificial soda, due to Leblanc, about 1789, for example, has been of great importance. There is hardly a chemical process in which this important product is not employed. This bit of paper, this glass, this painting, the linen which we wear, our coats, in the manufacture of all of them soda plays an important rôle. Formerly, soda was obtained only from vegetable ashes. Once its composition was determined, it was possible to produce it directly. An immense economy has thus been effected, and at the same time a great change in the location of wealth. Artificial soda is the object of a commerce amounting to many millions. Formerly, soda was obtained from Alicante and the coasts of Spain. The progress of chemistry has transported the source of supply to Sicily, the principal producer of sulphur. But notice how nothing can take the place of the energy of a people. It is not Sicily but England which has benefited. Coloring matters afford an analogous example. The progress of chemistry, in utilizing the by-products of the gas house, has ruined Guatemala, from which cochineal was imported. Thus is established the great law that the most industrial nation, that is to say, the most scientific nation, surpasses the other nations, and that the nation which is not industrial, that is to say, the nation which is not scientific, is at the mercy of a discovery which may at any moment dry up the fountain of her wealth. In a word, the existence of communities is more and more dependent upon science. And do not think that this is true only of applied science. The application is always the outcome of the most abstract theories. Not one of the applications which we have enumerated would have been possible without the Lavoisiers, the Thenards, the Berthelots, and the many other learned chemists who are the glory of our century.

Agriculture itself, that extremely practical industry, has benefited greatly by the fruits of abstract science. Consider how much effort of the human arm has been supplanted by agricultural machines, by the enormous threshing machines, for instance. Remember how arduous was the labor of the harvest formerly! Now a machine takes the place of all that effort, and makes it useless. Recall the revolution in the wealth of the State produced by the manufacture of beet sugar. And artificial manures; there again is a direct application of science. Formerly, before the advance in chemistry, natural substances were regarded only as specific compounds, and treated as such, and long and painful journeys were undertaken in search of them. Now we know their elements and we take these elements wherever we find them; we compound these elements ourselves and are no longer obliged to search for the compound where nature has made it. Great economy results from this, and every economy is so much gained for the people, as it diminishes the labor necessary to procure a pleasure or a necessity.

I pause, and yet what might I not say of the benefits which humanity has derived from physiology, from the sciences of life? Formerly, a certain cutaneous malady was considered incurable, constitutional in the last degree; its treatment was forbidden. Now it is effectually cured in a very short time. And when we shall walk boldly in the path opened by the Claude-Bernards and the Robins, there are no limits to what we may hope for. A host of ills considered incurable will be relieved or even removed entirely.

Have I succeeded in showing that studies apparently restricted to a limited number of people are the fruitful mothers of discoveries by which all benefit; that the people have a greater interest in them than the savants who labor to increase the sum of human knowledge; that the most valuable inventions result from labors begun in solitude and obscurity? And these inventions are as nothing to those that might be made, and the benefit which has resulted to the people is as nothing compared to that which is yet to accrue to them. Consider that it is scarcely a hundred years since science was seriously applied to the needs of life. If new inventions and machinery are at times a temporary cause of trouble and distress to the workman, it is due to the unfortunate fact that social transformations work themselves out slowly, at least that they do not keep pace with inventions; it takes time to re-establish the equilibrium. But I have no fears for the future. I am convinced that the progress of mechanics and of chemistry will be the redemption of the workingman, that the physical labor of humanity will go on always diminishing in quantity, and becoming less arduous; that thus humanity will be more free to lead a life happy, moral, intellectual. Hitherto, the culture of the intellect has been only a luxury, because material needs are imperious and these must be satisfied first of all. The essential condition of progress is that the satisfaction of these needs shall become more and more easy, and it is not too rash to foresee a future in which, with some hours of not arduous labor, man will discharge his labor debt, and redeem his liberty. Be assured that it is to science that this result will be due. Love science, respect her, believe in her! She is the best friend of the people, the most certain guarantee of their progress.

And what if I should speak of the moral and historical sciences, of the principles of gentleness, of toleration, of humanity, which are the most definite result of modern philosophy? What if I should tell of the light thrown upon the nature and history of humanity by researches which, apparently, are purely special; of the guidance drawn from the study of the past for the direction of the present? The charter of the rights of the people was the discovery of the savants. Voltaire—that is to say, the man who has done most to establish in the world the empire of good sense, of justice, and of toleration—Voltaire was the product of these moral and historical studies. It was the study, often profound, of the past, which revealed to him how many are the evils engendered by ignorance, by superstition, by prejudice. Turgot and Condorcet also drew from their immense knowledge that admirable sentiment for progress which should give them as high a place among the benefactors of the human race.

Science, which is often regarded as a sort of haughty aristocracy, is, on the contrary, that which teaches respect for the people; through it are made plain their history and their future. Science is like a cascade which has its source in the glaciers of the mountains, in the midst of the snows, in an atmosphere in which few people can breathe. Thence it flows down in a thousand rivulets, it comes within reach of all, it is a blessing to all. Let us be on our guard lest, under the pretext that the glacier whence the cascade comes is high above us, we deny its benefactions. To use another simile, let us beware of being like the savage who cuts down the tree to get the fruit. There is a real danger in that, but I hope that modern society will avoid it. Some superficial persons see the practical results of science, and think it possible to attain them directly, without the theories of chemistry and physics, without mathematics, which have given birth to these prodigies. With these persons, only the applications count. They wish to have the fruit without the tree, the consequences without the principle.

I am not one of those who disquiet themselves unduly over this error of some individuals. I do not believe that the democracy shares in it. The future belongs to the democracy, in intellectual matters as in work of all kinds; some day it will be necessary to reckon with everybody, and not with certain privileged classes. That which the democratic régime will one day honor with its favor will be, I fancy, very aristocratic. The art which the people will encourage one day will be great art and not the prettinesses which please in a decadent age. Notice that in a museum the people never pause before what are called the "genre" pictures; they go at once to the pictures with great subjects. In 1848, in the public readings, only the finest things were successful, Corneille, for instance. The literature which the people shall inspire will be, I hope, a noble literature, addressing itself to lofty sentiments, and not a frivolous literature of smart things and elegancies of construction. The style which the people will wish will be pure French, simple and natural, not a mannered tongue, varying with every wind of doctrine which individual fancy may attempt to create. I even hope that the future democracy, without entering into the detail of science, will grasp instinctively its spirit and its range. The people will understand that the progress of positive research is the most definite acquisition of humanity, and that this acquisition is more important than all else to those whom it delivers and ennobles. A world without science means slavery; it means man turning the millstone, in subjection to matter, living like a beast of burden. The world ameliorated by science will be the kingdom of the spirit, the dominion of free men.

Let us unite in this hope. Faith in progress is the great consolation of those who work and struggle for the future. Let us recall the illustrious Condorcet. In 1793, a victim of the Revolution for which he, more than any one, had prepared the way, we see him proscribed, forced to flee. He finds an asylum, in the suburbs of Paris, in the house of a devoted friend. What does he do in his retreat, with death hanging over him? He writes an admirable book, the picture of the future progress of the human intellect. What courage! Death menaces him every hour; a less heroic soul would have cursed that ungrateful Revolution which wished to kill him. He has, for the present, neither anger nor reproach; not for a moment is he disturbed; he writes his book. Menaced by the blindest fanaticism, he thinks out the ideal which will one day be realized. Admirable serenity of a sage! Even while iniquity and tyranny are in the ascendant, he proclaims the near triumph of liberty and justice. Not for an instant does his pen tremble. Scarce a sound from without penetrates to his retreat. One day a scrap of a public print brings to him the text of the terrible law against the suspects, which doomed to death any one who gave shelter to a proscribed person. Then he announces to the brave woman who had sheltered him, Madame Vernet, that he is going to leave her. "I am an outlaw," he said. "But I," she answered, "am not without humanity." He escapes, lives many days in the woods of Clamart. Hunger obliges him to leave his hiding place; a few days later he is dead. Let us not mourn over his memory; he had his faith, that faith which, when the heavens are overcast, opens the future for us, that faith which assures us that those who follow us will enjoy the fruit of our labors. Following his example, let us be unmoved by passing trials; let us, like Condorcet, know how to hope in the hour of storm for the happier days, when humanity, grown wise, will profit by the efforts of those who have labored and sacrificed themselves for it. E. RENAN.